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## ASSESSMENT OF SOVIET ELECTRICAL BRAIN STIMULATION RESEARCH AND APPLICATIONS

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### PREFACE

Electrical stimulation of the brain (ESB) is the process of applying electrical current to the cortex and deep structures of the brain through electrodes implanted by means of stereotaxic surgery. The electrodes are insulated except for a small area around the tip, and application of electrical current allows the experimenter to stimulate a predetermined area of the brain. The subsequently evoked behavior is observed and any changes in the subjects' somatic or mental state are attributed to the effect of the electrical stimulation. ESB is most frequently employed in the US and Soviet Union to aid the neurological conditions of tremor and spasticity found in patients with hyperkinesis, epilepsy and Parkinson's disease. The Soviets are reported to have used ESB on "normal" subjects, those who are not ill or otherwise impaired, to elicit a behavior response. This study attempts to assess the status of Soviet research in this field and to gauge the progress, if any, they may have made in applying ESB techniques to controlling human behavior.

### CONCLUSIONS

It is believed that in the USSR normal human beings have been used for electrical brain stimulation experiments.

The Soviets appear to have less stringent regulations on scientific experiments with normal human beings than does the West and therefore have an advantage, since any breakthrough in understanding how ESB

affects complex human behavior will most likely result from experiments with human subjects.

A survey of Soviet research on electrical brain stimulation to date has produced no evidence that the Soviets have been able to develop methods of controlling complex human behavior through ESB, nor that they have found significant applications of electrical brain stimulation techniques beyond standard therapeutic uses.

### SUMMARY

In 1968 it was reported that the Soviets were studying the effects of electrical stimulation on normal human brains. This report, and ensuing reports, prompted speculation that the Soviets were attempting to develop methods of controlling an individual's behavior or motor responses.

The Soviets declared in 1951 that one aim of their physiological research programs was to develop the ability to damage, repair, and control the central nervous system at will. During the late 1950s and early 1960s when Soviet scientific research changed rapidly, it was noted that the Soviets revitalized their interest

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in the biophysics of behavior and were devoting a larger portion of their resources to the study of human behavior than was the West.

The method of chronic use of imbedded electrodes in humans was introduced in the USSR in 1962 by Dr. Natal'ya Bekhtereva, a leading Soviet neurophysiologist with an international reputation. In 1966 at a meeting of French and Soviet scientists Dr. Bekhtereva reported she was using over 200 human subjects to study complex aspects of human behavior, memory, and encephalographic measurement. At that time the physical and mental health of the subjects was not mentioned. In 1968, however, at an International Symposium devoted to research on the Central Nervous System, Bekhtereva and Dr. Natalya Zavalova stated that normal humans had been subjects in experiments employing depth electrode implants. According to Bekhtereva, not all of the human subjects for her experiments were ill or otherwise impaired. Dr. Zavalova claimed to have

discovered that pilots took significantly less time in correcting an emergency situation during flight when electrodes implanted in their brains were stimulated. In 1972 Dr. M.I. Shik, in studying animal physiology and locomotion at the Gelfand Institute, Moscow, reported that electrical stimulation of the midbrain evoked many complex motor behavior activities. Dr. Shik expressed a worry that such research might be misused by Soviet authorities to control human behavior by appropriate application of brain stimulation techniques.

The Soviets use basically the same surgical techniques as the US for implanting electrodes and positioning the electrodes in the brain.

Although Soviets scientists have observed a large variety of responses from motor effects to emotional reactions there is no evidence that they have developed methods of controlling complex human behavior through ESB.

## DISCUSSION

Soviet experimentation on electrical stimulation of the brain with normal human subjects has prompted speculation that this technique is being developed as a means of controlling behavior. On the one hand, there is concern that the behavior of people might be shaped by stimulation of brain areas controlling muscular movements, while on the other hand, it is speculated that the human capacity to resist control could be effectively eliminated by the administration of powerful rewards and punishments delivered electrically directly to the brain. Although numerous physiological laboratories are actively engaged in studies of animal physiology involving electrical stimulation experiments, the Institute of Experimental Medicine in Leningrad is the only institute reported to be studying the effects of electrical stimulation on mentally and physically ill and normal human subjects.

Although the status of ESB research on animals has progressed steadily in the Soviet Union, such research in humans has only recently been done. Prior to the early 1960s there was virtually no research being conducted in the Soviet Union on implantation of recording or stimulating electrodes in the subcortical regions of the human brain. This hesitancy was in part

possibly the result of an aversion to the type of medical experiments performed by the Nazis during WWII. Nevertheless, in 1951 the Soviets openly stated that one aim of their physiological research programs was to develop the ability to damage, repair, and control the central nervous system at will.

During the late 1950s and early 1960s the nature of Soviet scientific research changed rapidly. Growing scientific interest in military and civilian space activities, along with an emphasis on scientific competition with the US, gave impetus to more varied scientific experiments. Soviet withdrawal from the rigidly Pavlovian-bound research philosophy led to a revitalized interest in the biophysics of behavior, particularly with regard to the bioelectrical features of subcortical areas of the brain. In the opinion of several prominent Western scientists who attended a symposium on Soviet research on the central nervous system and behavior in 1958, the Soviets were devoting a larger portion of their manpower, financial, and institutional resources to the study of human behavior than was the West. By the mid-1960s this shift in emphasis of Soviet philosophy and accompanying research was also reflected in the widespread use of depth recording in humans. The

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method of chronic use of imbedded electrodes in humans was introduced in the USSR by Leningrad researcher Natalya Petrovna Bekhtereva in 1962.

Since data obtained in experimental studies in animals cannot entirely explain the physiology of the human brain, experiments done with human subjects provide the most valid data. Most Western scientists adhere to strict rules limiting their electrode implantations for diagnostic purposes. Similarly, much of the research on electrical stimulation of the brain in the Soviet Union has been conducted concurrently with the basic clinical activity of diagnosing and treating patients, particularly those suffering from severe movement disorders manifested in Parkinsonism and epilepsy. In these cases, electrodes are implanted to locate more precisely the target site in order to make it possible to destroy smaller amounts of brain tissue. One Soviet scientist has allowed such electrodes to remain implanted for periods of several months. A US scientist who visited a physiology laboratory in Leningrad in 1968 and observed a depth electrode implantation in a Parkinsonian patient, reported that the depth electrode implantations were left in place for up to 6 months. According to the scientist, this was standard practice. Even though there have been cases in the US in which electrodes have been left in place for 6 months in treating Parkinsonian and epileptic patients, it is not standard procedure. Usually the electrodes are left in place no longer than a month on the average.

Some of the most sophisticated brain implant work is reportedly being done by Bekhtereva, a specialist in electroencephalography (EEG). During her career at the Leningrad Neurosurgical Institute (from 1954-1962), Bekhtereva used depth electrodes for EEG analysis. While at the Neurosurgical Institute she started using electrodes for stimulation of the brain. In 1962 the Soviet Academy of Medical Sciences transferred her to the Institute of Experimental Medicine where she was placed in charge of the Department for Applied Neurophysiology. She was later appointed Director of the Institute and in 1972 it was reported that she headed a research team of 100 professionals and several hundred technicians. There, she has implemented a program which concentrates on human brain work involving the implantation of electrodes in the brain for varied periods of time.

The Soviets probably also with "normal subjects"—those with no physical or mental impairment—to assess the possibility of controlling behavior for other than therapeutic purposes. Bekhtereva reported in 1966 at a meeting of French and Soviet scientists that there were 200 human subjects at her Institute with deep implanted electrodes participating in experiments on stimulation control of human behavior, memory and encephalographic measurement. Her basic premise was that the experimentation was necessary for the study of illnesses. When questioned on the number of subjects by a US scientist who suggested that she meant 20 rather than 200, she reportedly emphasized that the figure was in excess of two hundred. When questioned again in 1968, at an International Symposium on the Central Nervous System, Bekhtereva would only reply that the subjects were all Parkinsonian or epileptic patients and that the number was in excess of 100. However, a distinguished Western scientist reported that in an informal discussion, Bekhtereva indicated that not all her subjects were physically ill or otherwise impaired.

In the opinion of a US neurophysiologist, if Bekhtereva poses a requirement to the chairman of the Soviet Academy of Medicine, the Academy could arbitrarily transfer the required number of patients to her for research purposes. If in fact Bekhtereva has experimented with normal human subjects, it is highly improbable that these subjects were volunteers. Unlike Western medicine, obtaining human subjects for experimentation has not presented a problem in the Soviet Union. In the late 1950s Vasiliy V. Parin, director of the Institute of Normal and Pathological Physiology, admitted to a visiting Western colleague that obtaining human subjects for experiments was absolutely no problem. The use of coercive, often painful, medical treatment under the guise of psychiatric rehabilitation reportedly has been employed in the Soviet Union to silence political dissenters. Prisoners have been injected with drugs that produce a variety of reactions from Parkinson's syndrome to stupor. In addition, some prisoners are reportedly threatened with the use of electrical-shock "therapy." Thus, it would probably not be unusual for Soviet neurophysiologists to perform experiments with electrical stimulation on human subjects from the prison population.

The Soviets reportedly also are willing to use military subjects for electrical stimulation of the brain

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experiments with military application. Dr. Natalya Zavalova, a Soviet psychologist is reportedly in charge of psychological testing and training for flight personnel in the Soviet Air Force. At an International Symposium devoted to research on the Central Nervous System in the US in February 1968, Dr. Zavalova reported that she had implanted electrodes in the brains of jet pilots. Actually, Zavalova's experiment was divided into two parts. The purpose of the first phase of her experiment was to examine the capability of aircraft pilots to make decisions under stress. These pilots were placed in either aircraft or simulators with a second pilot who had been directed to maneuver the aircraft into dangerous flight attitudes. The procedures the subject pilots were asked to perform to correct the "emergency" were not pre-announced and the "stress" situation in which they found themselves was reportedly life threatening. Assessments of their reaction times during response to the emergency were recorded.

The second phase of the experiment was devoted to examining the impact of electrical brain stimulation on the capability of aircraft pilots to make decisions under stress. The exact same procedures were followed, however, this time when the plane was maneuvered into dangerous flight altitudes, the electrodes in the pilots brains were simultaneously stimulated. Zavalova claimed that fear was controlled in the pilots when the electrodes were stimulated and that this control was indicated when pilot performance of emergency procedure checks was reduced from 30 to 5 seconds.

Zavalova indicated that this experiment was undertaken to aid in the development of reliable methods for differentiating performance capabilities of pilots. There was no indication of where the testing took place. A Western scientist who talked to Zavalova reported that she admitted that her experiments with Soviet Air Force personnel were not well received by the aviators. Even though the aviators complied with all of her requests, there was a strong feeling among the pilots that her activities were totally unnecessary. In the open literature reprint of Zavalova's paper only the first phase of the experiment was discussed. In the opinion of a US neurophysiologist who knows both Drs. Bekhtereva and Zavalova, the electrode implant phase of the study was probably not actually supervised by Zavalova but rather by Bekhtereva or one of her colleagues at the Institute of Experimental Medicine.

At the 19th International Astronautics Conference in October 1968 from which Zavalova was conspicuously absent, it was rumored that she had been temporarily exiled to the Crimea on a six to eight month forced vacation. If true, it may suggest that she presented too much information at the earlier Conference and was in disfavor as was claimed by one source. Thus the contradiction between the open literature and what Zavalova reported informally, along with the rumor of her exile, tends to reinforce the speculation that Soviet electrical brain stimulation research with normal subjects is being conducted and may be partially classified in some instances.

Despite reported experiments with human subjects, the mechanics of Soviet stereotaxic surgery appear to be basically the same as those applied in the US. At present, differences in technique are attributable to the individual scientists' preference rather than a serious lag in scientific know-how. The most obvious technical difference is in the material used for the electrodes. Although many Soviet scientists use platinum or stainless steel electrodes as in the US, Bekhtereva's group consistently uses gold. It appears that they used a number of different metals such as graphite, silver, and stainless steel before deciding on gold. Bekhtereva has stated that the use of stainless steel was discarded due to the high noise levels associated with the metal. Since the use of stainless steel has not posed a serious problem for US scientists since about the 1950s it may be that Bekhtereva's problem was due to the use of an inferior type of steel.

Electrodes used for stimulation and recording are usually between 50-100 microns in tip diameter. Electrodes used for lesions may be of similar diameters or much larger depending on the area to be destroyed. Although recent US research shows a trend in decreasing the size of the gross recording electrodes to reduce trauma during implantation, US neurophysiologists for the most part use electrodes of approximately the same tip diameter. Reportedly, in 1968 Bekhtereva used the same electrodes for recording and stimulation. The main drawback with this procedure is that using the same electrode for stimulation produces a momentary depolarization thereby temporarily destroying the effectiveness of the electrode for recording. According to a US neurophysiologist, Bekhtereva was aware of this problem and indicated during an informal discussion that the problem was "avoided as far as possible."

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Another US neurophysiologist who is well acquainted with Bekhtereva's work reported in 1975 that most likely Bekhtereva is using gold electrodes to evaluate the oxygen content of the tissue and for recording but that another metal is used for stimulation.

In both the US and Soviet Union, cerebral atlases are normally used in preparing for the stereotaxic operations. In the mid-1960s, Bekhtereva's group developed a technique for transfer of cartesian to polar coordinates so that with the use of a computer the depth and direction of the electrode could be estimated during surgery. The first step in the implantation is to insert one electrode and take X-ray pictures in several planes. Angles are measured on these X-ray films and the data is fed to the computer. The computer then provides an immediate answer giving the necessary lengths and directions for all other electrodes. This use of the computer to calculate electrode coordinates serves not only to reduce the time involved but also increases the reliability of hitting preset brain structures with many electrodes and thus provides comparability of results obtained on different patients. According to open literature, the computer used is the Minsk-1. The Minsk series of computers are most commonly employed in scientific research. Even though the Minsk-1 is limited in the type and speed of data input and output and is not solid-state, it is capable of performing the data manipulations needed for the stereotaxic surgery.

Soviet scientists also use encephalography to assist in electrode placement. With the use of an on-line computer analysis of average EEG frequency the scientist is able to pinpoint more precisely the position of the electrodes. With this slight variation, the contrast roentgenological exams after surgery confirm the electrode position.

In general the Soviets allocate equipment in terms of the priority of the research being done. According to a western scientist who visited Soviet Brain Research Facilities in 1972, the brain research laboratories had comparatively excellent equipment. He reported that about half of the laboratory equipment was made in Japan, especially the electron microscopes, while oscilloscopes were of Czechoslovak origin. Hungary supplied fine mechanical tooling, while most photographic equipment and film came from East Germany. Contrary to Bekhtereva's reported use of the Minsk-1 computer, he reported that most of the brain research computers were solid-state computers

manufactured in Yerevan, Armenia. The computers the distinguished scientist saw may have been those located in a central computer center servicing all the physiology labs in the institutes and therefore capable of performing functions other than the basic types of computer analysis needed by Bekhtereva's group. Since Bekhtereva is one of the top neurophysiologists in Soviet electrical brain stimulation research, it is quite probable that the lab within the Institute of Experimental Medicine which does the ESB data analysis has its own computer.

Soviet scientists performing electrical brain stimulation research have observed both simple and complex changes in mental activity during these experiments. Some of these changes include fluctuations in waking states, simple visual and auditory hallucination, diverse psychosensory disturbances and "body scheme" disorders, changes in memory, mood fluctuations, and development of attraction to repeated electrical stimulation inducing pleasant emotions. In general, electrical stimulation of the brain can produce a large variety of responses, from motor effects to emotional reactions. Some of these observations have raised questions among scientists regarding whether humans can be manipulated in such a manner that they can be transformed (in the words of one Soviet scientist), into "robots." This fear has been perpetuated by the fact that the Soviets appear to have more of an opportunity to experiment with normal human subjects rather than any hard and fast statistics on their actual capability to control human behavior through application of electrical brain stimulation.

Western scientists are in general agreement that purposive, complex motor behavior cannot be generated through electrical stimulation of the brain. Soviet scientists at the Gelfand Institute of Information Transmission Problems, however, in studying the physiology of locomotion, have reported that stimulation of the midbrain region evokes locomotion in animals including many complex motor behavior activities such as climbing, jumping, running, and walking. Although their research does not indicate that this complex behavior is purposive, M. L. Shik, a member of Gelfand research team, expressed fear that such research could be misused by Soviet authorities.

Although Soviet brain stimulation studies may provide some information about the way the brain is

organized to control movements, the inability to predict the sequence of responses that will be elicited indicates that this phenomenon has little practical application. Most Western neurophysiologists believe that even though the flexion of a limb could be radio controlled and an emotional state artificially induced, the sequences of responses and adaptation to the environment depend on well established intracerebral mechanisms whose complexity cannot be duplicated by electrical stimulation of the brain.

Unique possibilities for studying the neurophysiological bases of various mental phenomena are provided by the method of implanted electrodes. No anatomical structures have been identified by either US or Soviet scientists which "control" memory thereby allowing localization of this center. The currently favored Soviet position regarding the location of memory is similar to that of the US, namely, the "functional" centers of memory are located in a variety of places in the brain and operate in concert.

Bekhtereva reportedly has found, from stimulation of the thalamic region, a tendency toward euphoria on the part of patients which some have interpreted as the opposite to a fear center. The experiment reported by

Zavalova in which purportedly the fear of pilots in stressful situations was eliminated was most likely an attempt to further corroborate evidence of a fear center.

A neurophysiologist who visited the Institute of Experimental Medicine in Leningrad reported in 1972 that Bekhtereva's group was planning to treat mental disorders with electrode implants and noted that this was a tool of great potential danger. Bekhtereva has recently stated that they are treating schizophrenia with electrical stimulation of the brain. During this treatment, electrodes are implanted into the brains of patient who then leaves the hospital for 6 months. After the 6 month period, the patient returns for necessary follow-up treatment. She mentioned that epilepsy may be treated by the same procedure. No further details were given. Although electrodes have been implanted in the brains of epileptic patients in the US for treatment purposes, the implantation of electrodes in the brains of patients suffering from schizophrenia has thus far only been used in clinical research to help clarify the nature of schizophrenia. In essence, the use of ESB to "treat" schizophrenia is without precedence in the West. (SECRET) (NO FOREIGN DISSEM)